Laser-Induced Incandescence Measurements of Particulate Matter Emissions in the Exhaust of a Diesel Engine

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ABSTRACT

Particulate matter (PM) emissions have been simultaneously measured by laser-induced incandescence (LII) and the standard gravimetric procedure in a mini dilution tunnel connected to the exhaust of a single-cylinder DI research diesel engine. The engine used in this study incorporates features of contemporary medium- to heavy-duty diesel engines and is tuned to meet the U.S. EPA 1994 emission standards. The engine experiments have been run using the AVL 8-mode steady-state simulation of the U.S. EPA heavy-duty transient test procedure. Results of the PM concentrations measured using the two methods are compared, the primary particle sizes are determined on a mode-by-mode basis, and the use of LII for comparing the PM emissions from four different fuels is demonstrated.

Results have shown that:

1. The use of three wavelength detection to determine particle surface temperature, combined with absolute sensitivity calibration, provides a sensitive, precise, and repeatable measure of the particulate concentration over a wide dynamic range
2. The LII technique produces good correlation with the gravimetric filter method measurements on a mode-by-mode basis over a wide range of operating conditions.
3. The primary particle size can be determined from the LII signals, and that this method is precise enough to distinguish particle sizes for different operating conditions.
4. Once the particulate concentration and primary particle size are known, it is possible to determine the number density of primary particles.
5. LII has also been shown to be sensitive in differentiating the PM performance between four different fuels, predicting the same trends in brake specific PM emissions as the gravimetric filter method.

The LII technique is capable of real-time particulate matter measurements over any engine transient operation, making it a valuable tool in tuning diesel engine PM emissions performance. The wide dynamic range and lower detection limit of LII make it a potentially preferred standard instrument for PM measurements. Further development of the LII technique has the potential to give information about extensive aspects of the morphology of the particulate matter. Use of LII also provides a significant time advantage over the gravimetric procedure, both in the collection and processing of data.